"Back-of-the-Envelope" Estimates of Momentum Resolution in the MIPP Spectrometer

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An accompanying document from us discusses the impact of the TOF wall on momentum resolution in the MIPP spectrometer and on noise in the RICH. This study shows that even a 5 cm thick TOF wall does not have a major impact on the overall momentum resolution. We believe these simulation results to be correct and precise, but in regard to momentum resolution there are a few interesting questions that this work does not address. In our simulation study the information gleaned from all available components of the spectrometer is folded together to produce the plots of resolution vs. p. Therefore these plots do not reveal what each of the components is contributing to the bottom line. The purpose of this back-of-the-envelop study is to expose in a qualitative way the contributions of the various parts of the spectrometer to the momentum measurement. Our conclusion is that the TOF wall seriously degrades the information derived from the chambers downstream of the ROSIE magnet. Degradation in the overall momentum resolution is modest because the components upstream of ROSIE are able to shoulder the task on their own.

We present five plots of momentum resolution vs. p from 5 to 50 GeV. The following statements give the context for all of them.

- "JGG resolution" (appears in all figures) uses the TPC in conjunction with chamber 3 (just upstream of TOF/ROSIE), or with chamber 5 (just downstream of ROSIE), or with chamber 6 (downstream of the RICH).
- The JGG field is 0.7 T, and the magnetic length is 75 cm, which is supposed to represent the path length from the midpoint of the TPC to the downstream edge of the JGG field.
- The TPC is deemed to provide infinite precision in position and angle at its midpoint and to have a massless rear window.
- We take the ROSIE field to be -0.6 T, and its magnetic length to be 1.5 m.
- We take the spatial resolution of the drift chambers to be 0.2 mm.
- We include multiple coulomb scattering in the gas of the Cerenkov counter and in its windows. For the thickness of both windows, however, we assumed 0.003 rl, which has little effect compared with the gas (0.028 rl). (N.B. the simulation study does not incorporate multiple scattering in the Cerenkov counter.)
- We took the drift chamber material and the RICH as well as intervening air to be "invisible."

In Fig. 1 the ROSIE momentum measurement depends on chamber pair 1,3 or 2,3 (the better of the two) to measure the track angle upstream of the magnet and chamber pair 4,6 to measure the angle downstream of the magnet. Fig. 2 differs from Fig. 1 by the substitution of chamber 5 for chamber 6. Both figures include JGG resolution from TPC to chamber 3 for reference. The lesson we derive from these figures is two-fold. First, as one adds thickness to the TOF wall, the measurement exclusively from bend in the ROSIE field deteriorates dramatically. Second, under no circumstances does the measurement using only the ROSIE field do as well as what one achieves using the JGG field and components upstream of ROSIE. Note that the actual JGG measurement will be better than we show in these figures because it will incorporate data from chambers 1 and 2 as well as the curvature within the TPC.

For amusement we show in Figs. 3, 4, and 5 what would be observed if the ROSIE field were turned off and chambers 5 and 6 were used with the TPC to measure bend in the JGG field. Fig. 3 shows clearly the benefit of a longer lever arm when the TOF is not permitted to gum up the works. Figs. 4 and 5 show that with a 1 cm TOF wall this benefit survives only above 25 GeV, and with a 5 cm TOF wall it is almost eradicated.

If the TOF wall, of whatever thickness, does no significant damage to the overall momentum resolution, why might one have an interest in minimizing its thickness? With a thin TOF we can have two largely independent measurements of the momentum of comparable accuracy. Then there exists the opportunity to beat one against the other in the hope of understanding, if not reducing, systematic error. The only other benefit of a thin TOF that has come to our attention is noise reduction in the RICH, which we treat in the companion document. In conclusion, we hope that this document gives a more complete picture of the impact of the TOF wall on momentum resolution and will strengthen the foundation of understanding on which we base the selection of a design.

Fig. 1. Resolution from ROSIE using chamber downstream of RICH.

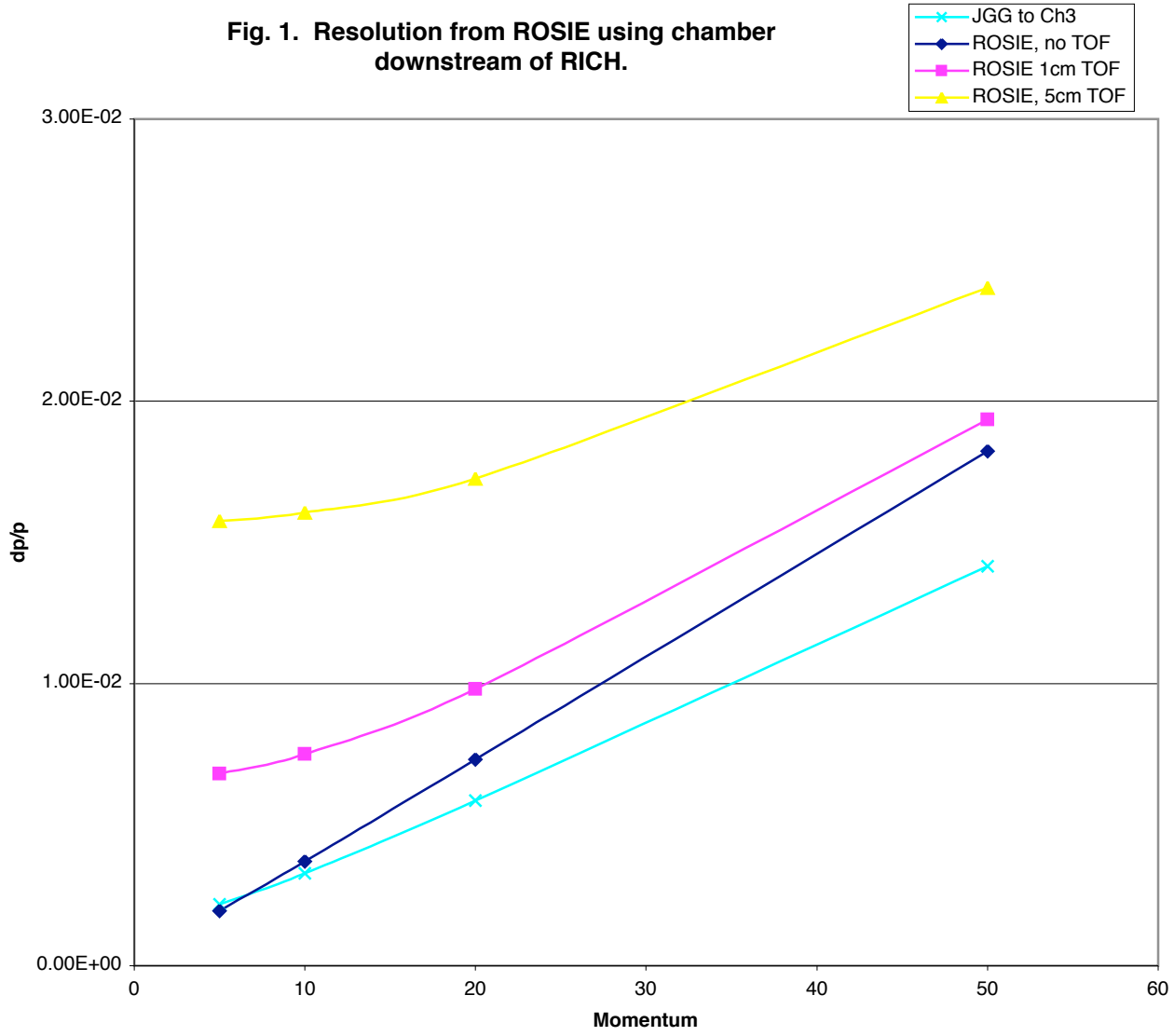

Fig. 2. Resolution from ROSIE using chambers upstream of RICH.

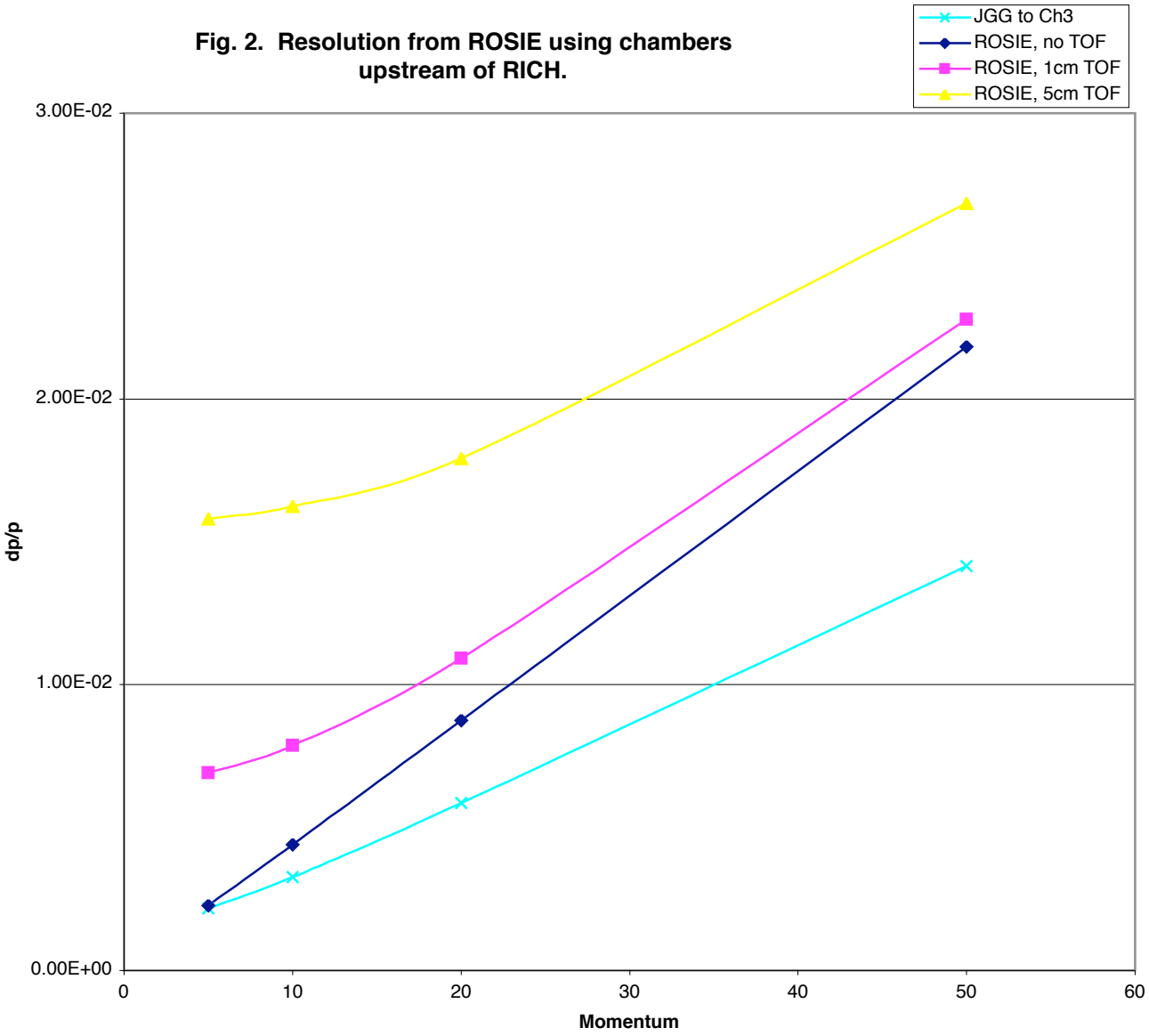

Fig. 3. Resolution from JGG using TPC and Chambers 3, 5, and 6 (ROSIE off, no TOF).

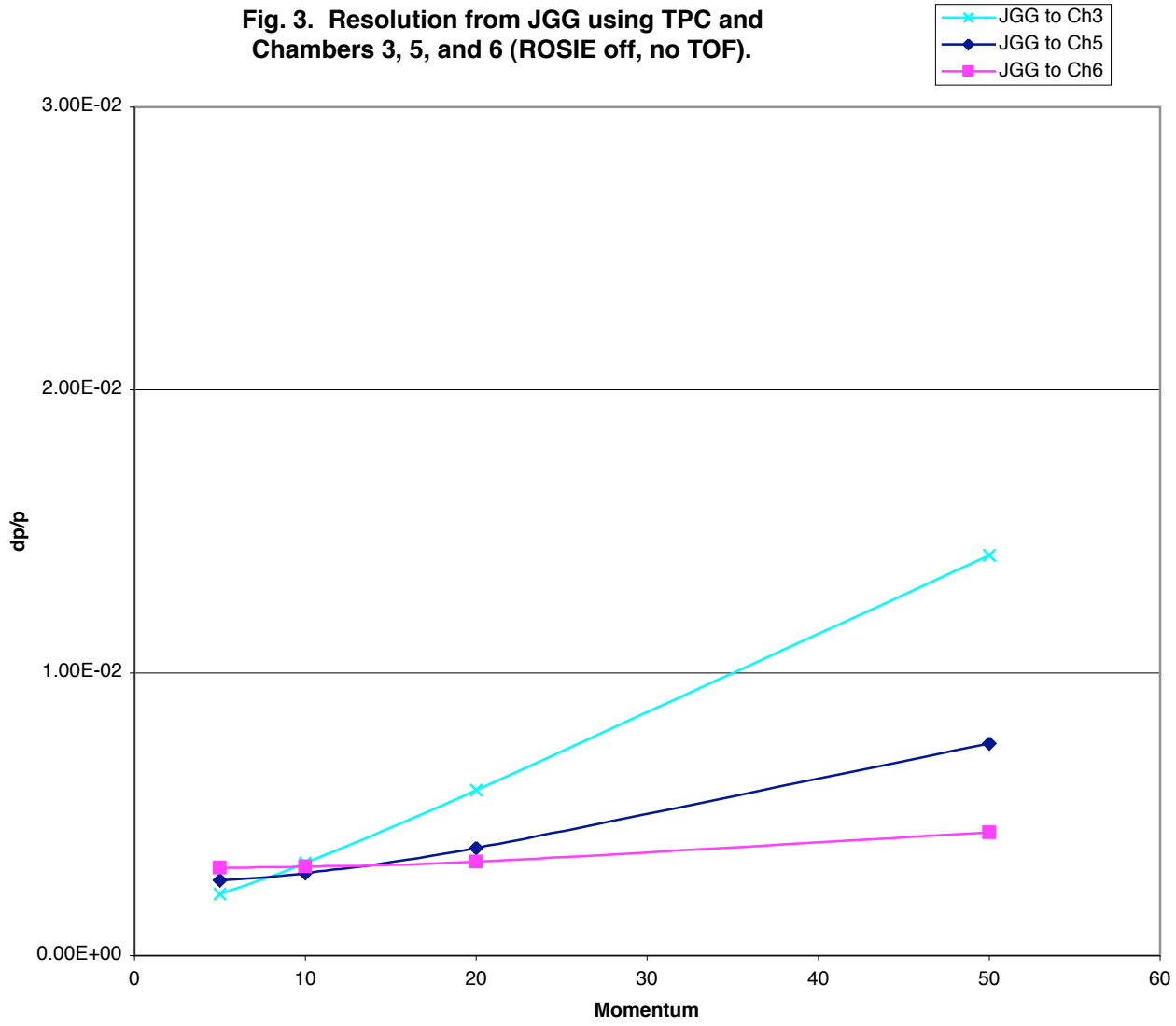

Fig. 4. Resolution from JGG using TPC and Chamber 5 (ROSIE off).

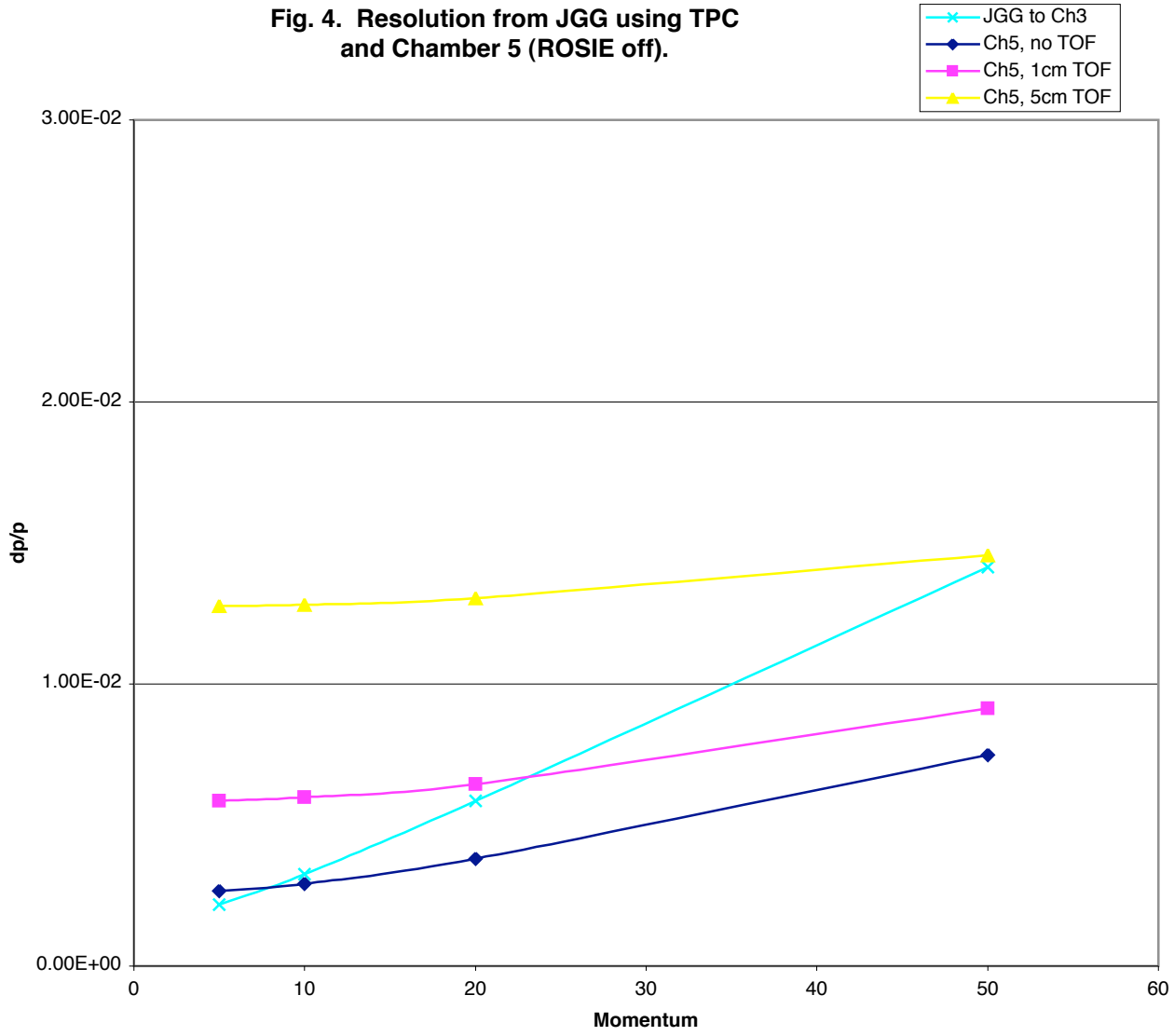

Fig. 5. Resolution from JGG using TPC and Chamber 6 (ROSIE off).